International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.8, pp 3996-4001, September 2014

ICSET-2014 [6th – 7th May 2014]
International Conference on Science, Engineering and Technology

Analysis the Effect of Heavy and Toxic Metals in Various Vegetables Grown in Vellore District (South India)

Saikat Sinha Ray, Amsavel, J. John Joseph, D. Sangeetha*

Environmental Analytical Chemistry DivisionSchool of Advanced Sciences, VIT University Vellore - 632014, Tamil Nadu, India

***Corres.author: dsangeetha@vit.ac.in**

Abstract : The project will study the effect of heavy and toxic metals present in various vegetables grown in South India (Vellore District). Simultaneously the project will make the use of different standard methodologies and analytical instrumentations for the quantitative analysis of heavy and toxic metals. In next half of the experiment Transfer Factor (TF) and Daily Intake Rate (DIR) will also be calculated. The toxicity of these metals is in part due to the fact that they accumulate in biological tissues, a process known as bioaccumulation. Even the toxicity level and reasons for increasing concentration of toxic metals were also studied for each and every vegetable for that region. This toxicity may lead to various types of paralysis, neurological disorders and cancer. Therefore in conclusion some sort of agricultural management will be suggested for the welfare of environment point of view.
Keywords: Toxic metals, South India, Vegetable samples, Analysis.

Introduction

As we came across a lot of research works on vegetables and fruits throughout the world. But there are some important areas in India where such kind of research works have not been done so far. The analysis has been done in order to get sufficient information about the content of heavy and toxic metals in various vegetables in southern region of India (Vellore District). The vegetable samples were collected from mainly industrial places of Vellore District (India).

Environmental pollution due to heavy and toxic metals has become a health concern for all over the world. Biological accumulation of some metals such as lead (Pb) and mercury (Hg) in human body may disturb the proper functioning of the mitochondria i.e "power house of cell" [1].

There are some metals such as copper (Cu), iron (Fe), manganese (Mn), vanadium (V) could serve as plant nutrients depending on particular concentration level [2]. As far as analysis is concerned heavy metals such as chromium (Cr), copper (Cu), nickel (Ni), cadmium (Cd), mercury (Hg) and lead (Pb) have been studied [3].

Thus heavy and toxic metals were observed along with the safe limits of EPA (Environmental Protection Agency), WHO (World Health Organization), NAFDAC (National Agency for Food and Drug Administration and Control)[4].

Materials and Methodology

Collection of Samples

The various vegetables samples (9 vegetables) were collected from the different sites in Vellore district (India). The name of the vegetables which were taken for the analysis are as follows: Cabbage (*Brassica oleracea),* Onion (*Allium cepa),* Carrot (*Daucus carota)* Spinach (*Spinacia oleraceae),* Beans (*Phaseolus coccineus),* Cauliflower (*Brassica oleracea),* Brinjal (*Solanum melongena),* Potato (*Solanum tuberosum),* Tomato *(Lycopersicon esculentum).* These vegetables were thoroughly examined and hence authenticated by Dr. P. Jayaraman, Director, Institute of Herbal Science, Plant Anatomy Research Centre, Chennai. Even the soil samples were also collected where these vegetables were grown for future reference. The samples were cut into small pieces by stainless steel knife and then dried for 2 days in favourable conditions and after that these vegetables were kept in hot air oven maintaining the temperature of 80 °C for 24 hours. After this the dried samples were kept in muffle furnace for 30 minutes maintaining the temperature about 450 °C then black ash of the samples were crushed and made into fine powder by the help of mortar and kept in polythene bag [5].

Sample Treatment

Two grams of each vegetable sample was taken in volumetric flask which was digested with 60% HClO4 per chloric acid, (5 ml), concentrated HNO3 nitric acid (10 ml) and H_2SO_4 sulphric acid (5ml) and placed on hot plate for 1 hour. On cooling, the digested samples were filtered into a 100 ml volumetric flask and made up upto the mark. For checking the contamination, blanks were also prepared. Similarly, for the soil sample HF is used in place of sulphuric acid for digestion purpose [6].

Metal Analysis

As far as metal analysis is concerned the heavy and toxic metals (Cu, Cr, Ni, Cd, Hg and Pb) were studied by the Atomic Absorption Spectroscopy in VIT TBI (VARIAN AA240 AAS).

Result:

As previously mentioned that 9 vegetable samples were taken from different sites in Vellore District (South India). Even the soil samples were also taken for the reference of Transfer Factor (TF) i.e., transfer of metal concentration from soil to vegetables/ plant parts. Table 1 shows the heavy and toxic metals concentration of various vegetables taken for the analysis. As far as the analysis is concerned Cu, Cr, Ni, Cd, Pb and Hg were determined.

Table 2 shows the concentration of metals of the soil taken from farmland in which various vegetables were grown. Simultaneously the Transfer Factor (TF) was calculated for each vegetable sample.

Next the safe limit of heavy and toxic metal concentration has been shown given by WHO, EPA and NAFDAC. For the human welfare point of view DIR i.e., Daily Intake Rate will also be calculated for various vegetables. Lastly the threat level has been calculated and shown by taking the reference value from safe limits of each heavy and toxic metal.

Fig- Map showing the different places of Vellore district where vegetables and soil samples were collected.

Table 1 Shows concentration of heavy and toxic metals in various vegetable

Sample/ Metal concentration	Cabbage mg/l	Cauliflower mg/l	Onion mg/l	Potato mg/l	Tomato mg/l	Beans mg/l	Carrot mg/l	Brinjal mg/l	Spinach mg/l
Cu	2.163	3.563	5.516	2.095	2.589	2.223	1.669	3.532	2.572
Cr	1.10	8.928	9.511	8.506	9.949	9.562	0.052	5.052	6.771
Ni	0.212	0.251	0.212	0.207	0.296	0.318	0.088	0.252	0.687
Cd	0.135	0.061	0.073	0.082	0.045	N.D	0.052	0.039	0.064
Pb	2.96	1.27	3.91	3.92	1.65	0.22	1.34	1.87	1.54
Hg	3.20	1.64	1.71	1.32	2.93	0.91	4.80	N.D	4.01

Table 2 Shows concentration of heavy and toxic metals in soil of various sites

Soil sample/	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Concen-Tration of metals	(cabbage) mg/l	(cauliflower) mg/l	(onion) mg/l	(potato) mg/l	(beans) mg/l	(carrot) mg/l	(brinjal) mg/l	(tomato) mg/l	(spinach) mg/l
Cu	N.D	4.521	2.156	2.365	1.089	2.025	3.962	2.595	1.117
Cr	N.D	8.977	16.145	10.362	5.465	N.D	9.588	9.989	8.442
Ni	0.367	0.341	0.252	0.216	N.D	N.D	0.313	0.047	0.734
Cd	0.896	N.D	0.084	0.087	N.D	0.138	0.061	N.D	0.896
Pb	N.D	2.04	3.78	3.21	N.D	2.72	1.95	1.72	2.31
Hg	1.81	N.D	2.91	2.90	1.11	5.91	1.01	3.1	1.71

(NOTE: N.D – Not detectable)

Table 3 Shows Transfer Factor (TF):

Soil sample/	Site 1 (cabbage)	Site 2 (cauli - flower)	Site 3 (onion)	Site 4 (potato)	Site 5 (beans)	Site 6 (carrot)	Site 7 (brinjal)	Site 8 (tomato)	Site 9 (spinach)
Transfer percentage									
Cu	N.D	0.78	2.55	0.88	2.04	0.82	0.89	0.99	2.31
Cr	N.D	0.99	0.58	0.81	1.75	N.D	0.52	0.99	0.80
Ni	0.57	0.73	0.84	0.95	N.D	N.D	0.80	6.29	0.93
Cd	0.15	N.D	0.86	0.94	N.D	0.37	0.63	N.D	0.07
Pb	N.D	0.62	1.03	1.22	N.D	0.49	0.95	0.95	0.66
Hg	1.77	N.D	0.58	0.45	0.81	0.81	N.D	0.94	2.34

(Note: N.C- Not detected)

Transfer Factor can be calculated by the given formula:

T.F = (concentration of metal in plant parts /concentration of metal in soil)

Effects of toxic and heavy metals :

1. **Copper (Cu) :** copper is one of the important nutrient required by the human body. But exceeding the safe limit given by NAFDAC and WHO may lead to gastrointestinal problem. Even it may cause dysfunction of metabolism of other nutrients. The safe limit proposed by NAFDAC and WHO is 2.5 mg/kg in vegetables.
2. **Chromium (Cr) :** Chromium may affect the respiratory tract, stomach and small intestine if the concentration of Cr exceeds the safe limit of 5.0 mg/kg. Even it may affect the male reproductive system.
3. **Nickel (Ni) :** An uptake of too large quantities of nickel has the following consequences: - Higher chances of development of lung cancer, nose cancer, larynx cancer and prostate cancer. Asthma and chronic pain.

The safe limit given by WHO/ NAFDAC is 2.0 mg/kg in vegetables.

4. **Cadmium (Cd) :** Kidney is the main target as far as the toxicity of cadmium is concerned. Accumulation of cadmium may lead to renal tubular dysfunction. It may cause lung cancer as it is highly carcinogenic in nature. The safe limit of Cd is 0.05mg /kg [7].
5. **Lead (Pb) :** Lead is one of the prominent metal that is carcinogenic in nature. The accumulation of lead in human body may cause cancer as it will damage the mitochondria of the cell. As far as the safe limit is concerned it is about 1.0mg/kg in vegetables [8].
6. **Mercury (Hg):** Mercury is the most toxic element found in the atmosphere. Long duration of exposure may lead to cancer and neurological disorders. It may lead to paralysis also if it exceeds the safe limit of 1.0 mg/kg.

Table 4: Safe limits proposed by NAFDAC and WHO

METALS	NAFDAC (mg/l)	WHO (mg/l)
Cu	2.5	2.5
Cr	3.0	5.0
Ni	2.0	3.0
Cd	0.05	1.0
Pb	1.0	2.0
Hg	1.0	1.0

[NAFDAC : NATIONAL AGENCY FOR FOOD AND DRUG ADMINISTRATION AND CONTROL]

DIR (Daily Intake Rate) : It is one of the important parameter to calculate how much amount of metal is taken by an adult per day.

Mathematically it can be calculated by given formula :

DIR= Cm×Dintake/ Bavg

Where,

Cm- Concentration of metal. Dintake- Daily intake vegetable (kg/person).

Bavg- Average Body weight (55.9 kg)

The average vegetable intake was considered to be 0.345kg/person per day [9].

Table 5: Shows the Daily Intake Rate (DIR) for each vegetable.

Metals/ DIR	Cabbage (mg/kg)	Cauliflower (mg/kg)	Onion (mg/kg)	Potato (mg/kg)	Beans (mg/kg)	Carrot (mg/kg)	Brinjal (mg/kg)	Tomato (mg/kg)	Spinach (mg/kg)
Cu	0.013	0.022	0.034	0.012	0.013	0.010	0.0217	0.015	0.015
Cr	0.0069	0.055	0.058	0.0527	0.059	0.00032	0.031	0.062	0.04
Ni	0.0013	0.0015	0.0013	0.0012	0.0019	0.0005	0.0015	0.0018	0.004
Cd	0.0008	0.00037	0.0004	0.0005	ND	0.0003	0.00024	0.00027	0.00039
Pb	0.015	0.007	0.024	0.024	0.0013	0.0083	0.011	0.0102	0.009
Hg	0.020	0.010	0.010	0.010	0.0056	0.029	ND	0.018	0.024

Table 6 Shows the Threat level Percentage

Metal/ percentage	Cabbage	Cauliflower	Onion	Potato	Tomato	Brinjal	Beans	Carrot	Spinach
	%	%	%	%	%	%	%	%	%
Cu	0	40	0	0	3.2	40	0	0	3.2
Cr	0	196	215	110	230	68	216	0	123
Ni	0	0	0	0	0	0	0	0	0
Cd	170	22	46	0	64	0	N.D	1	28
Pb	196	27	291	292	65	87	0	34	54
Hg	220	64	71	32	193	N.D	0	380	300

Threat level percentage shows the percentage of threat when it is compared to the safe limit of concentration of metal in vegetables proposed by NAFDAC and WHO. As far as the threat level percentage is concerned, the content of Pb and Hg is considerably higher than the other metal content.

Thus there is a great chance of neurological disorders, cancer and paralysis if these vegetables were taken for long period of time. So it is the matter of great concern as 5,00,000 people die annually due to cancer in India.

Discussion :

The study has generalized that the concentration of metals in vegetables is found to be in following order : Cr > Cu > Pb> Hg> Ni > Cd.

The cadmium content in vegetable samples is very less as compared to other metals. Furthermore the Transfer Factor (TF) of Cu is found to be greater. The higher transfer factor of heavy metal indicates the stronger accumulation of the respective metals by that vegetable. The trend of transfer of these metal is found to be in the order of Cu > Hg > Cr > Pb > Ni > Cd.

The greater the transfer factor value than 0.50, the greater the chances of vegetables for metal contamination by anthropogenic activities will be there and so there is need for environmental monitoring of area is required. Daily Intake Rate is very useful for assessment of human health hazard. The degree of toxicity of heavy metals to humans depends on the daily intake. The safe limit for DIR for toxic metals such as Pb, Cd, Hg is about 0.005 mg per person per day. So as far as the analysis and DIR is concerned Pb and Hg show beyond the safe limit given by WHO/FAO. Thus there is some possibility of having neurological disorders, cancer and even paralysis if these vegetables were taken for long duration. Among possible human target organs of heavy metals, are soft tissues such as the kidney, liver and the central nervous system. Some patients develop vesicular type of hand eczema following ingestion of Ni. Threat level percentage is also calculated by taking the references of the safe limits proposed by NAFDAC and WHO. The content level of Pb, Hg and Cr in the vegetables is found beyond the safe limit and hence for few samples the threat level percentage is more than 100 %. So according to the threat level percentage there is a trend that has been found to be in order of Hg > Pb > Cr > Cd > Cu > Ni. From the metal analysis we can infer that Ni content in various vegetables is found to be in safe limit as there is 0 % threat level.

Conclusion

Analysis of heavy and toxic metals concentration in vegetables and food products is important for human health risk. Such type of analysis is quite helpful for farmers as well as agricultural researchers so that they can adopt a healthy strategy which will help in saving mankind from cancer and other critical diseases. The content level of Pb and Hg may harm the human health by inducing in the cells and hence it may disrupt the mitochondria (power house of cell). South India is one of the cancer prone regions according to some reports. So as far as the analysis is concerned some agricultural management is highly recommended in order to reduce

the toxicity in food chain. In other words there is a great chance of human health hazards if these vegetables were taken for a very long period. However continuous usage of these farmlands for growing crops could lead to bioaccumulation of these metals and their eventual entry into the food chain with the associated health risks being manifested.

References

1. Opaluwa, O. D., Aremu, M. O., Ogbo, L. O, Abiola, K. A., Odiba, I. E.,Abubakar, M.M., Nweze, N.O; Advances in Applied Science Research, 2012, 3 (2):780-784.
2. J. C. Akan, B. G. Kolo, B. S. Yikala, V. O. Ogugbuaja; International Journal of Environmental Monitoring and Analysis 2013, 1(2): 40-46.
3. Sajjad Khan, Robina Farooq, Maria Sadique Shahbaz; World Applied Sciences Journal, 2009, 6 (12): 1602-1606.
4. Y Y Choi, International / National Standards for Heavy Metals in Food.
5. Orish Ebere Orisakwe, Nduka John Kanayochukwu, Amadi Cecilia Nwadiuto, Dike Daniel and Obialor Onyinyechi; Environmental and Analytical Toxicology, 2012, 2(3).
6. Sadia Ata, Feroza Hamid Wattoo, Momina Feroz, Muhammad Hamid Sarwar Wattoo, Syed Ahmed Tirmizi, Muhammad Javaid Asad; Ethiopian Journal of Environmental Studies and Management, 2013, 6(4).
7. WHO.,Cadmium. Environmental Health Criteria, Geneva. 1992, Vol., 134.
8. 8.WHO., Lead. Environmental Health Criteria, Geneva. 1992, Vol. 165.
9. Vinod Jena, Satish Dixit, Sapna Gupta; International Journal of Research in Environmental Science and Technology, 2012.

***** *****